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Whatever the final orbit may be, I do not think any other can be made at this time to better represent the observations. It will be seen that this differs from Auwers' orbit of the theoretical star (*Ast. Nach.* 3084) by 2·57 years in the period. In some of the other elements the difference is a little more.

Chicago:
May 30.

Probable Errors of Greenwich Observations of Close Circumpolar Stars. By T. Lewis.

In the *Monthly Notices* for 1889 April, Mr. Downing gives the probable error of a result for R.A. as obtained with the Greenwich transit circle at different zenith distances, and for the four close circumpolar stars. He finds for λ *Ursæ Minoris*, δ *Ursæ Minoris*, and *Cephei* 51, whether above or below pole, sensibly the same result in equatorial arc, viz., $\pm^{s}\cdot030$; but for *Polaris* the result is $\pm^{s}\cdot020$.

This probable error includes not only the errors of observation, but those of the determinations of instrumental position. In nearly all cases where these stars have been kept "for place," the azimuthal error has been deduced from consecutive transits of *Polaris*, which doubtless accounts for the smaller value of the resulting probable error in the case of *Polaris*.

The results obtained by Mr. Downing for the circumpolars relate to eye and ear observations, whether over the fixed galvanic wires or over the same wire set to different readings of the transit micrometer. From 1889 January 1 these stars have been observed chronographically by moving the centre wire with the transit micrometer until the star is accurately bisected, and recording the instant of bisection on the chronograph with the left hand. Moreover, the list of circumpolar stars under constant observation at Greenwich has been increased (since 1888 September) by the addition of all those whose ephemerides are given in the *Connaissance des Temps*, or M. Lœwy's Annual Tables.

The following additional information with regard to the observation of close circumpolars is therefore of interest:—

(1) *The errors of bisection* and *of eye and ear estimates.* The separate bisections, or estimates of transits, were reduced to the centre wire and compared with the mean result. Observations of the close circumpolar stars, made both before and after 1889 January 1, were considered, and the results for each of the four regular observers kept separate. The probable errors are reduced to the equator.

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Observer.	λ Ursæ Min.		Polaris.		Cephei 51.		δ Ursæ Min.	
	E. and E.	Chron.	E. and E.	Chron.	E. and E.	Chron.	E. and E.	Chron.
	s	s	s	s	s	s	s	s
A. D.	±·013	±·016	±·011	±·019	±·023	±·021	±·024	±·018
T.	±·015	±·019	±·015	±·023	±·020	±·026	±·021	±·024
L.	±·010	±·017	±·013	±·016	±·017	±·022	±·023	±·020
H.	±·016	±·023	±·016	±·019	±·020	±·030	±·030	±·027
Mean	±·014	±·019	±·014	±·019	±·020	±·024	±·027	±·022

The probable error of an estimate is thus smaller than that of a bisection, which would seem to point to the E. and E. method being the more accurate for stars very near the pole. It is to be remarked, however, that in the eye and ear method the readings of the micrometer screw, and consequently the times of transit, were separated by equal intervals, and there might be a tendency to equalise the recorded intervals. In the chronographic method the intervals are quite unknown, and thus the observations are entirely independent. This, therefore, may readily be one of the cases where a smaller probable error indicates an inferior observation.

It is further to be remarked that the error of bisection increases with the N.P.D. To bring this out more prominently, other circumpolar stars were examined, and also a large number further from the pole. Some differences are shown by the several observers, but a detailed examination of these peculiarities is not made on this occasion.

Table II.

Star.	N.P.D.	P.E.	Group. N.P.D.	P.E. Above Pole.	P.E. Below Pole.
	° ′	s	° °	s	s
λ Ursæ Minoris	1·2	±·019	5–10	±·023	±·025
Groombridge 1119	1·2	±·018	10–15	·034	·035
Polaris	1·20	±·019	15–20	·039	·038
Bradley 1672	1·41	±·020	20–25	·040	·042
Groombridge 2283	2·20	±·019	25–30	·042	·044
Cephei 51	2·47	±·024	30–40	·049	·045
Bradley 3147	3·19	±·024	40–50	·054	·055
δ Ursæ Minoris	3·23	±·022			
2 Ursæ Minoris	4·20	±·028			
Bradley 2993	4·27	±·032			

The error is thus sensibly the same above and below pole to considerable polar distances, but the increase with distance from the pole is very marked up to 50°, when, from a discussion made by Mr. E. Dunkin, it would appear to remain practically constant. Here the chronographic method clearly showed to advantage.

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Mr. Dunkin's results in 1864[*] :—

N.P.D.	Probable Error of one Wire E. and E.	Chronographic.
° °	s	s
60–70	±·089	±·052
70–80	·082	·052
80–90	·073	·051
90–100	·070	·051
100	·070	·050

(2) As regards *the error of a result for R.A.*, there is, of course, nothing to add to Mr. Downing's results, except in the case of the four close circumpolar stars. Assuming ±^{s}·030 as the P.E. of a resulting R.A. for λ *Ursæ Minoris*, *Cephei* 51 and δ *Ursæ Minoris*, and ±^{s}·020 for *Polaris* from the E. and E. method, we should get theoretically for the P.E. of result for R.A. by the chronographic method:

	s
λ Ursæ Minoris and Cephei 51	±·031
δ Ursæ Minoris	±·029
Polaris	±·021

The actual P.E.'s from the observations in 1889 and 1890 (chronographic method) are :—

	s
Cephei 51	±·031
δ Ursæ Minoris	±·0295
λ Ursæ Minoris	±·026
Polaris	±·021

Agreeing well with the indirect method of combining error of bisection and instrumental error, except in the case of λ *Ursæ Minoris*.

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[*] *Monthly Notices*, vol. xxiv., p. 154.

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Observations of the Satellites of Saturn in 1893.

By the Rev. Alex. Freeman, M.A.

The observations were made with a refractor equatorially mounted and having an aperture of $6\frac{1}{2}$ inches; the focal length is nearly thirteen times the aperture. The power used was 116, being found most suitable for the purpose. By the term conjunction is meant a coincidence of position on a line normal to the ring-axis of *Saturn*. Results only are given for the moment of conjunction, though divergence from conjunction within 5^{m} before and after the actual conjunction was usually also noted. Greenwich Mean Time is employed.

February 3^{d} 12^{h} $14^{m}{\cdot}7$, *Enceladus* seen very near west elongation, due $12^{h}{\cdot}35$.

February 3^{d} 13^{h} $17^{m}{\cdot}4$, *Enceladus* was co-linear with *Tethys* and *Dione*, both south of line of ring-axis.

February 3^{d} 13^{h} $38^{m}{\cdot}0$, *Rhea* and *Tethys* very nearly in conjunction normally to ring-axis, and about one equatorial diameter of ♄ preceding west end of ring. The calculated distances of Rh. and Te. from polar axis of ♄ are $44''{\cdot}66$ and $44''{\cdot}46$ for the observed time.

February 14^{d} 12^{h} 1^{m}, *Rhea* very closely followed north part of ball of ♄, and was not yet up to the east tangent at end of *Saturn's* equator.

March 15^{d} 10^{h} 40^{m}, *Tethys* not yet up to west end of ring, cloudy soon after. (Te. θ, $10^{h}{\cdot}7$, Marth.)

March 19^{d} 11^{h} 18^{m}, *Tethys* half-ansa length from the ball of ♄ east. Within $0''{\cdot}9$ of tabular place.

April 12^{d} 11^{h} $45^{m}{\cdot}2$, *Dione*, south preceding, opposite middle point of line joining inner and outer ring-ends.

April 17^{d} 11^{h} $5^{m}{\cdot}7$, *Tethys* not quite up to east end of ring. 11^{h} $8^{m}{\cdot}2$, *Tethys* almost quite up. It then became cloudy. (Te. ζ, $11^{h}{\cdot}2$, Marth.)

April 20^{d} 9^{h} $53^{m}{\cdot}5$, *Dione* now fully up to east ring-end, south. (Di. ζ, $10^{h}{\cdot}1$, Marth.)

April 23^{d} 10^{h} 44^{m}, *Dione* was in conjunction with west end of Cassini division, south of ring.

April 23^{d} 11^{h} 19^{m}, *Dione* in conjunction with west end of ring, south. (Di. η, $11^{h}{\cdot}4$, Marth.)

April 30^{d} 10^{h} $49^{m}{\cdot}8$, *Titan* is now on the south polar axis of *Saturn* produced. The distance between the limbs of